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NASA TECH BRIEF

Lewis Research Center

Angular Magnetic Field Beam Improves Efficiency in Klystrons and Traveling Wave Tubes

An angular magnetic field produced by tapered wedges of high coercivity material like Samarium-Cobalt imparts a constant radial velocity to any particle passing through it independent of the axial velocity of the particle; axial particle trajectories can thereby be focused. Special lens shaping allows variation of focusing strength with radius. The lens can be either converging or diverging depending on the charge of the particles and the direction of the angular magnetic field. This type of lens will be useful in refocusing the spent beam of a klystron or traveling wave tube amplifier where the emerging electrons have a wide range of axial velocities.

This technique and the application of multistage axisymmetric depressed collectors should increase the efficiency of the electron tubes, now typically 35 to 45%, to 60 to 80%. Electrostatic lenses and single-coil, magnetic field lenses all have focusing properties which are very sensitive to the axial velocity of the beam particles (chromatic aberration). The angular magnetic field lens, while not free of chromatic aberration (due to the fact that not all electrons with the same axial velocity are focused at the same plane), imparts a constant radial velocity to each particle passing through it regardless of its axial velocity.

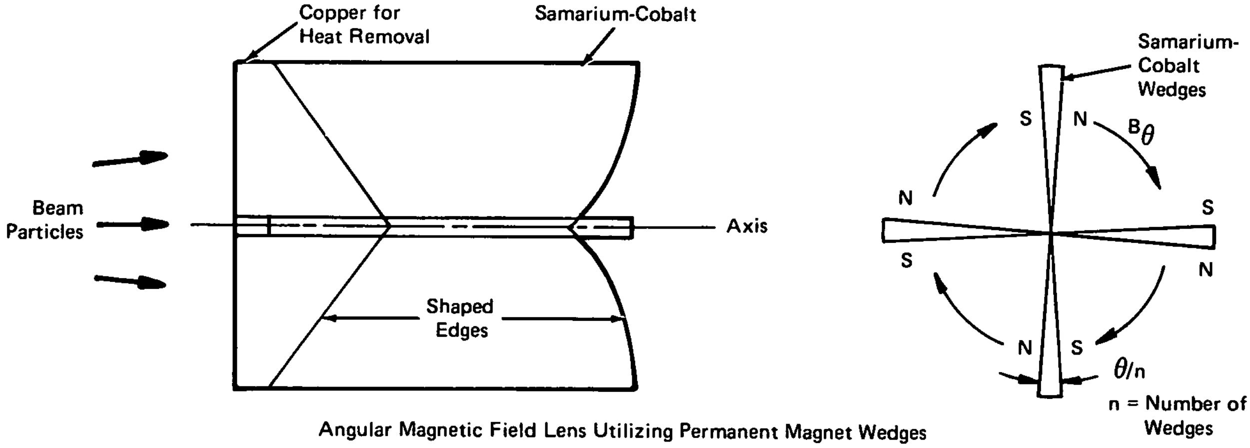
The permanent magnet version requires no external power supply and also allows optimization of the axial extent of the angular field by shaping the leading and trailing edges of the magnet structure.

As shown in the figure, the angular magnetic field is produced by shaped wedges of high coercive force material like Samarium-Cobalt magnetized in the direction shown. Since the coercive force for this material is approximately 8,000 oersted, the total angle θ occupied by the permanent magnet structure is typically quite small, and the transmission of the lens will be very good. The field strength is given by the approximate formula

$$B_\theta \approx \mu_0 H_c \left(\frac{\theta}{2\pi}\right)$$

where μ_0 is the permeability of free space, H_c is the coercive force of the material, and θ is the angle occupied by this material.

To remove the heat caused by particles that do intercept the structure, a set of leading copper wedges may be inserted. This would prevent the magnet material from overheating and possible loss of its useful properties. The leading and trailing edges of the permanent



Angular Magnetic Field Lens Utilizing Permanent Magnet Wedges

(continued overleaf)

magnet wedges are shaped as shown to indicate how the axial extent of the angular field may be controlled. This shaping allows a variation of the lens focal length with radius which may be optimized in any particular case.

Notes:

1. Since Samarium-Cobalt is extremely difficult to demagnetize and is highly anisotropic, a magnetic wedge type lens may be used in combination with an ordinary beam focusing coil to allow variation of the focal length and more optimum focusing.
2. The angular magnetic field lens can find application in any case where a constant radial velocity is to be impressed on all the particles regardless of their axial velocity. This means that the focal length of the lens is directly proportional to the axial velocity of the particles. For relativistic velocities this proportionality must be modified. Since lenses are not perfect, they do not have the exact same focal length for all particles of the same velocity passing through the lens at different points. If the magnetic field does not have the proper symmetry, chromatic aberration can occur.
3. There is potential use for this lens in particle analyzers, electron beam welding systems, microwave tube refocusing systems, and possible display type devices where this variation of focal length with particle energy can be exploited.
4. The following documentation may be obtained from:
   National Technical Information Service
   Springfield, Virginia 22151
   Single document price $10.50
   (or microfiche $0.95)

   Reference: NASA CR-121114 (N73-14217), Refocusing of the Spent Axisymmetric Beam in Klystron Tubes
5. Technical questions may be directed to:
   Technology Utilization Officer
   Lewis Research Center
   21000 Brookpark Road
   Cleveland, Ohio 44135
   Reference: B73-10206

Patent status:

Inquiries concerning rights for the commercial use of this invention should be addressed to:

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